# Unit Testing and JUnit

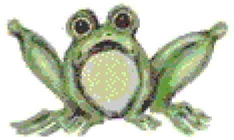
# Testing Objectives

- Tests intended to find errors
- Errors should be found quickly
- Good test cases have high *p* for finding a yet undiscovered error
- Successful tests cause program failure, i.e. find an undiscovered error.
- Tests should be mutually exclusive and exhaustive
- Minimal set of test cases needs to be developed because exhaustive testing not possible

## Unit Testing

- A unit is typically a method/class/a cluster
- Testing done to each unit, in isolation, to verify its behavior
- Typically the unit test will establish some sort of artificial environment and then invoke methods in the unit being tested
- It then checks the results returned against some known value
- When the units are assembled we can use the same tests to test the system as a whole

# Unit Testing Tool for java : JUnit



**JUnit is a framework for writing tests** www.junit.org

- JUnit was written by Erich Gamma (of Design Patterns fame) and Kent Beck (creator of XP methodology)
- JUnit uses Java's reflection capabilities (Java programs can examine their own code)
- JUnit features includes:
    - *Test fixtures for sharing common test data*
    - *Assertions for testing expected results*
    - *Test suites for easily organizing and running tests*
    - *Graphical and textual test runners*

- JUnit is not yet included in Sun's SDK, but an increasing number of IDEs include it
- BlueJ, JBuilder, Eclipse, DrJava etc.now provide JUnit support

# Structure of a JUnit test class

- Suppose you want to test a class named Complex
- public class ComplexTest
                  extends junit.framework.TestCase {
  - This is the unit test for the Complex class; it declares (and possibly defines) values used by one or more tests
- publicComplexTest() { }
  - This is the default constructor
- protected void setUp()
  - Creates a test fixture by creating and initializing objects and values
- protected void tearDown()
  - Releases any system resources used by the test fixture
- public void testAdd(), public void testEquals(), etc.
  - These methods contain tests for the Complex class methods add(), Equals(), etc.

## Example: Complex Class

```
public class Complex {
  int real_part; int imaginary_part;
  public Complex(int r, int i) {
    real_part=r;
    imaginary_part=i;
  }
  public Complex() {
    real_part=0;
    imaginary_part=0;
  }
  public boolean Equal(Complex c) {
     boolean result = false;
     if ((real_part==c.get_r()) && (imaginary_part==c.get_i())) result=true;
     return result;
  }
  public Complex Add(Complex c) {
    Complex result = new
                        Complex(c.get_r()+real_part,c.get_i()+imaginary_part);
    return result;
  }
  public int get_r() { return real_part;}
  public int get_i() { return imaginary_part; }
}
```

# Using JUnit (Create Fixture)

```
public class  ComplexTest extends TestCase {
   Complex c1;
   Complex c2;
   protected void setUp() {
      c1 = new Complex(7,3);
      c2 = new Complex(12,6);
   }
   protected void tearDown(){   }
}
```

## Using JUnit (Add Test Cases)

```
public void testAdd() {
   Complex result = c1.Add(new Complex(5,3));
   assertEquals(result.get_r(),c2.get_r());
   assertEquals(result.get_i(),c2.get_i());
}
public void testEqual(){
   assertTrue(!c2.Equal(c1));
   assertTrue(c1.Equal(new Complex(7,3)));
}
```

Note that each test begins with a *brand new* c1 and c2

This means you don't have to worry about the order in which the tests are run

## Two alternative to run Your tests

- Implicit

  - TestRunner uses reflection to determine the tests to be run i.e. methods starts with "*test*" prefix

```
public static void main(String [] args) {
        junit.textui.TestRunner.run(ComplexTest.class);
}
```

- Explicit

  - use of a *public static* method of TestCase class named *suite()*

  - explicitly naming the tests to be run

```
public static Test suite() {
        TestSuite suite = new TestSuite();
        suite.addTest(new ComplexTest("testAdd"));
        suite.addTest(new ComplexTest("testEqual"));
        return suite;
}
public static void main(String[] argv){
        junit.textui.TestRunner.run(suite());
}
```

## Writing a Test Case

- To write a test case, follow these steps:
  1. Define a subclass of TestCase.
  2. Override the setUp() method to initialize object(s) under test.
  3. Override the tearDown() method to release object(s) under test.
  4. Define one or more testXXX() methods that exercise the object(s) under test.
  5. Define a suite() factory method that creates a TestSuite containing all the testXXX() methods of the TestCase.
  6. Define a main() method that runs the TestCase.

# More Assert methods I

- assertEquals(***expected***, ***actual***)
  assertEquals(String ***message***, ***expected***, ***actual***)
  - This method is heavily overloaded: *arg1* and *arg2* must be both objects *or* both of the same primitive type
  - For objects, uses your equals method, ***if*** you have defined it properly, as public boolean equals(Object o)
  - --otherwise it uses ==

- assertSame(Object ***expected***, Object ***actual***)
  assertSame(String ***message***, Object ***expected***, Object ***actual***)
  - Asserts that two objects refer to the same object (using ==)

- assertNotSame(Object ***expected***, Object ***actual***)
  assertNotSame(String ***message***, Object ***expected***, Object ***actual***)
  - Asserts that two objects do not refer to the same object

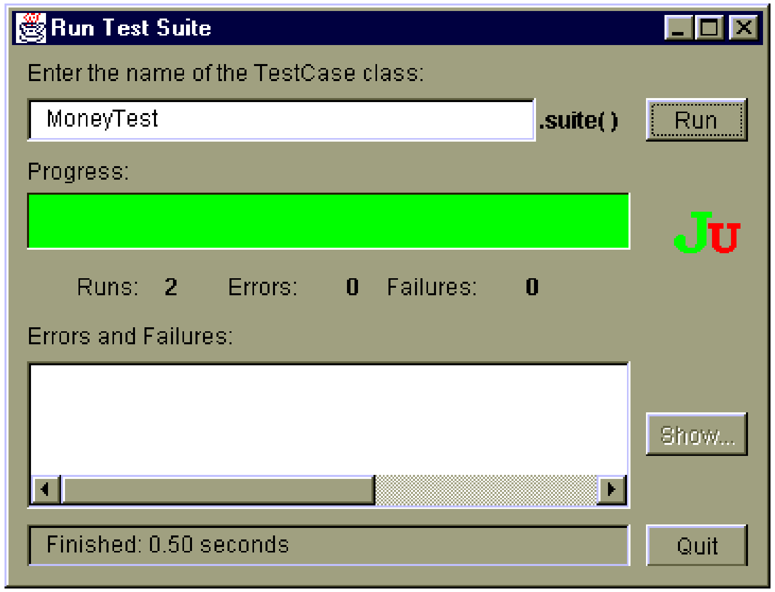
## More Assert methods II

- assertNull(Object ***object***)
  assertNull(String ***message***, Object ***object***)
  - Asserts that the object is null
- assertNotNull(Object ***object***)
  assertNotNull(String ***message***, Object ***object***)
  - Asserts that the object is null
- fail()
  fail(String ***message***)
  - Causes the test to fail and throw an AssertionFailedError
  - Useful for testing Exceptions

## Using Junit

- Download latest version (3.8.1) from: www.junit.org
- Setup classpath to junit.jar
- Write TestCase classes and organize them (Import junit.framework.*)
- Include appropriate JUnit TestRunner in main()

# JUnit GUI Test Runners

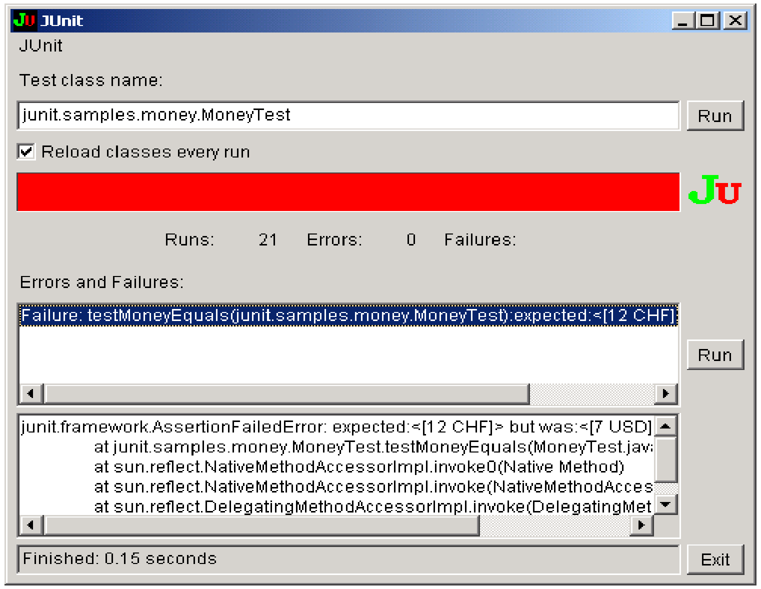


Runs: 2 Errors: 0 Failures: 0

Errors and Failures:

Finished: 0.50 seconds

**Figure 1**: A Successful Run (awtui)



junit.samples.money.MoneyTest

✓ Reload classes every run

Runs: 21 Errors: 0 Failures:

Errors and Failures:

Failure: testMoneyEquals(junit.samples.money.MoneyTest):expected:<[12 CHF]

```
junit.framework.AssertionFailedError: expected:<[12 CHF]> but was:<[7 USD]
        at junit.samples.money.MoneyTest.testMoneyEquals(MoneyTest.java
        at sun.reflect.NativeMethodAccessorImpl.invoke0(Native Method)
        at sun.reflect.NativeMethodAccessorImpl.invoke(NativeMethodAcces
        at sun.reflect.DelegatingMethodAccessorImpl.invoke(DelegatingMet
```

Finished: 0.15 seconds

**Figure 2**: An Unsuccessful Run (swingui)

## Unit Testing (without tool support)

## Complex Class: revisited

```
public class Complex {
  int real_part; int imaginary_part;
  public Complex(int r, int i) {
    real_part=r;  imaginary_part=i;
  }
  public Complex() {
    real_part=0; imaginary_part=0;
  }
  public boolean Equal(Complex c) {
     boolean result = false;
     if ((real_part==c.get_r()) &&
     (imaginary_part==c.get_i())) result=true;
     return result;
  }
  public Complex Add(Complex c) {
    Complex result = new
    Complex(c.get_r()+real_part,c.
                         get_i()+imaginary_part);
    return result;
  }
  public int get_r() { return real_part;}
  public int get_i() { return imaginary_part; }
}
```

```
public static void main(String[] argv)
{
Complex c1 = new Complex(7,3);
Complex c2 = new Complex(12,6);
Complex result = c1.Add(new
Complex(5,3));
if (result.get_r()==c2.get_r() &&
              result.get_i()==c2.get_i())
System.out.println("Addition test Passed");
else
 System.out.println("Addition test Failed");
if (!c2.Equal(c1))
System.out.println("Equality test I
Passed");
else
 System.out.println("Equality test I Failed");
```

## Organizing and Running Tests

- To run your tests, you need:
- An instance of a TestRunner class.
- An instance of your test class (named *MyTestClass* for the purposes of this example) containing the tests you want to run. *MyTestClass* must extend junit.framework.TestCase.
- Some way of telling the chosen TestRunner instance which tests on your *MyTestClass* instance to run.

# Organizing Tests Hierarchies:
## An Example:

```
import junit.framework.TestCase;
public class MyTestClass extends TestCase {
 public MyTestClass(String name) {
                super(name);
      }
      public void runTest() {
                testTurnLeft();
                }
      public void testTurnLeft() { ... code here ... }
}
```

```
import junit.framework.TestCase;
public class CalculatorTest extends TestCase
{ public CalculatorTest(String name) {
                super(name);
      }
      public void runTest() {
                 testIsDivisor();
                }
      public void testIsDivisor() { ... code here ... }
}
```

```
import junit.framework.TestCase;
public class MyThirdTestClass extends TestCase {
 public MyThirdTestClass(String name) {
                super(name);
      }
public void test1() { ... code here ... }
public void test2() { ... code here ... }
}
```

## A hierarchy of Tests to run

```
public static suite() {
 TestSuite testSuite = new TestSuite();
 testSuite.addTest(new MyTestClass("testTurnLeft"));
 testSuite.addTest(new CalculatorTest("testIsDivisor"));
 testSuite.addTest(new TestSuite(MyThirdTest.class));
return testSuite;
}
```

# Problems with unit testing

JUnit is designed to call methods and compare the results they return against expected results

- This works great for methods that *just* return results, but some methods have side effects
  - To test methods that do output, you have to capture the output
    - It's possible to capture output, but it's an unpleasant coding chore
  - To test methods that change the state of the object, you have to have code that checks the state
    - It's a good idea in any case to write self-tests for object validity
- It isn't easy to see how to unit test GUI code

## Conclusions

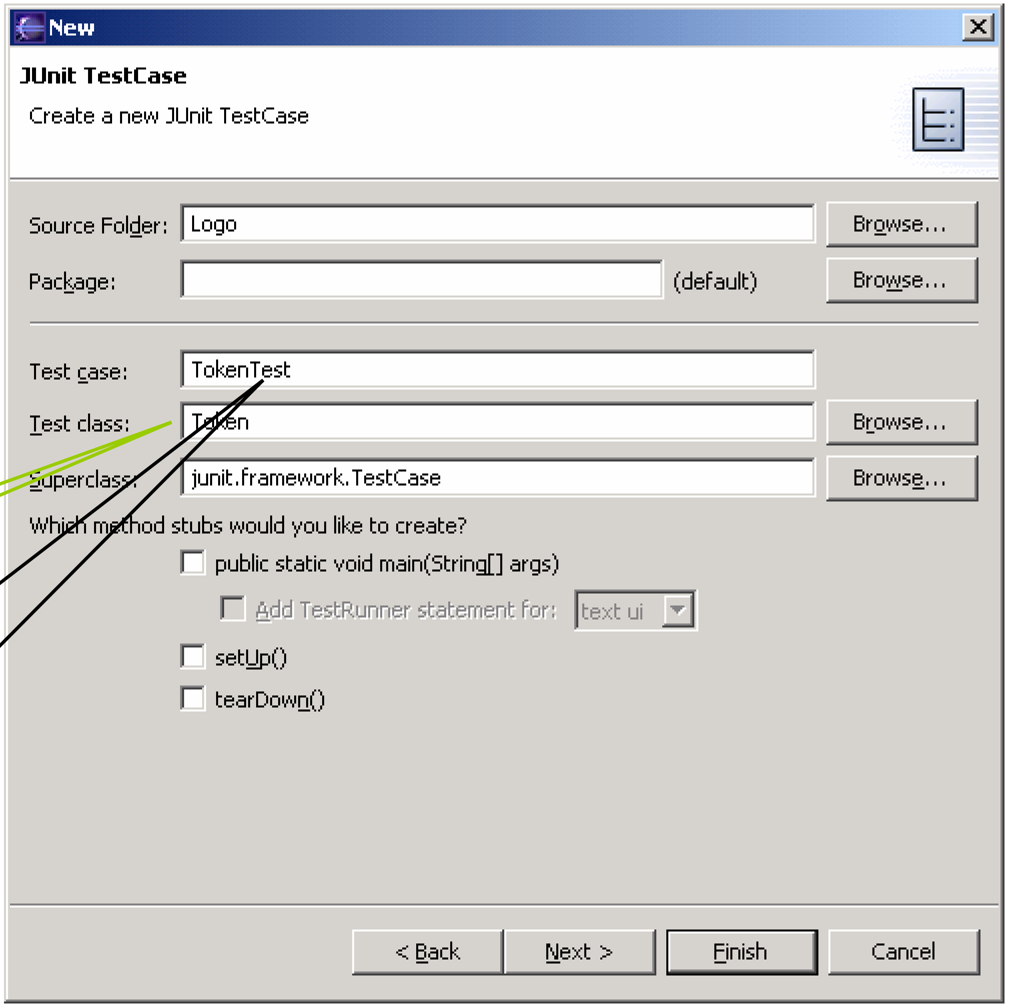
- Unit Testing is the place to identify and remove errors at the earliest
- Effective Automated tests can be written to test most of the units, if not all
- Unit Testing Frameworks (UTF), like JUnit are quite useful in writing, executing and organizing unit tests for incremental code development and change management.

# JUnit in Eclipse

- To create a test class, select File→ New→ Other... → Java, JUnit, TestCase and enter the name of the *class you will test*

Fill this in

This will be filled in *automatically*



New

JUnit TestCase

Create a new JUnit TestCase

Source Folder: Logo

Package: (default)

Test case: TokenTest

Test class: Token

Superclass: junit.framework.TestCase

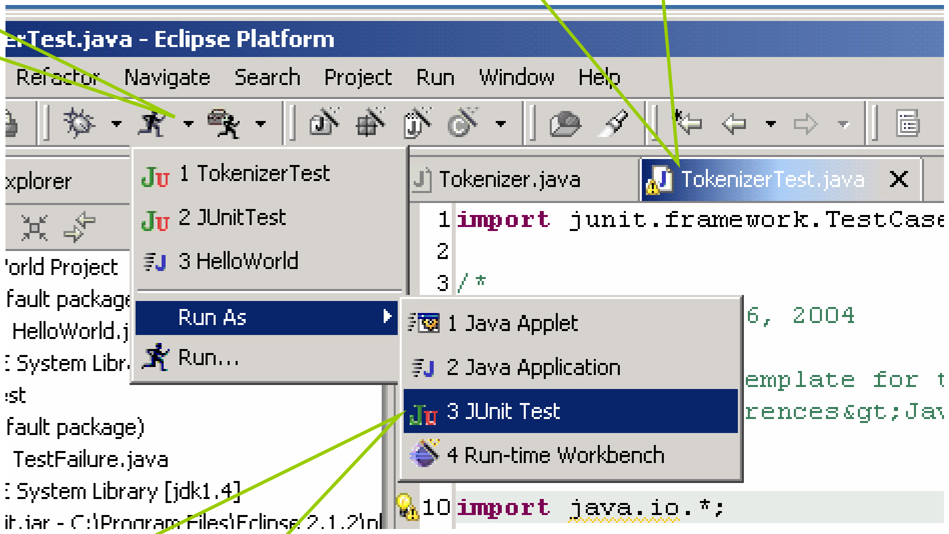
Which method stubs would you like to create?

- [ ] public static void main(String[] args)
- [ ] Add TestRunner statement for: text ui
- [ ] setUp()
- [ ] tearDown()

# Running JUnit

Second, use this pulldown menu

First, select a *Test* class

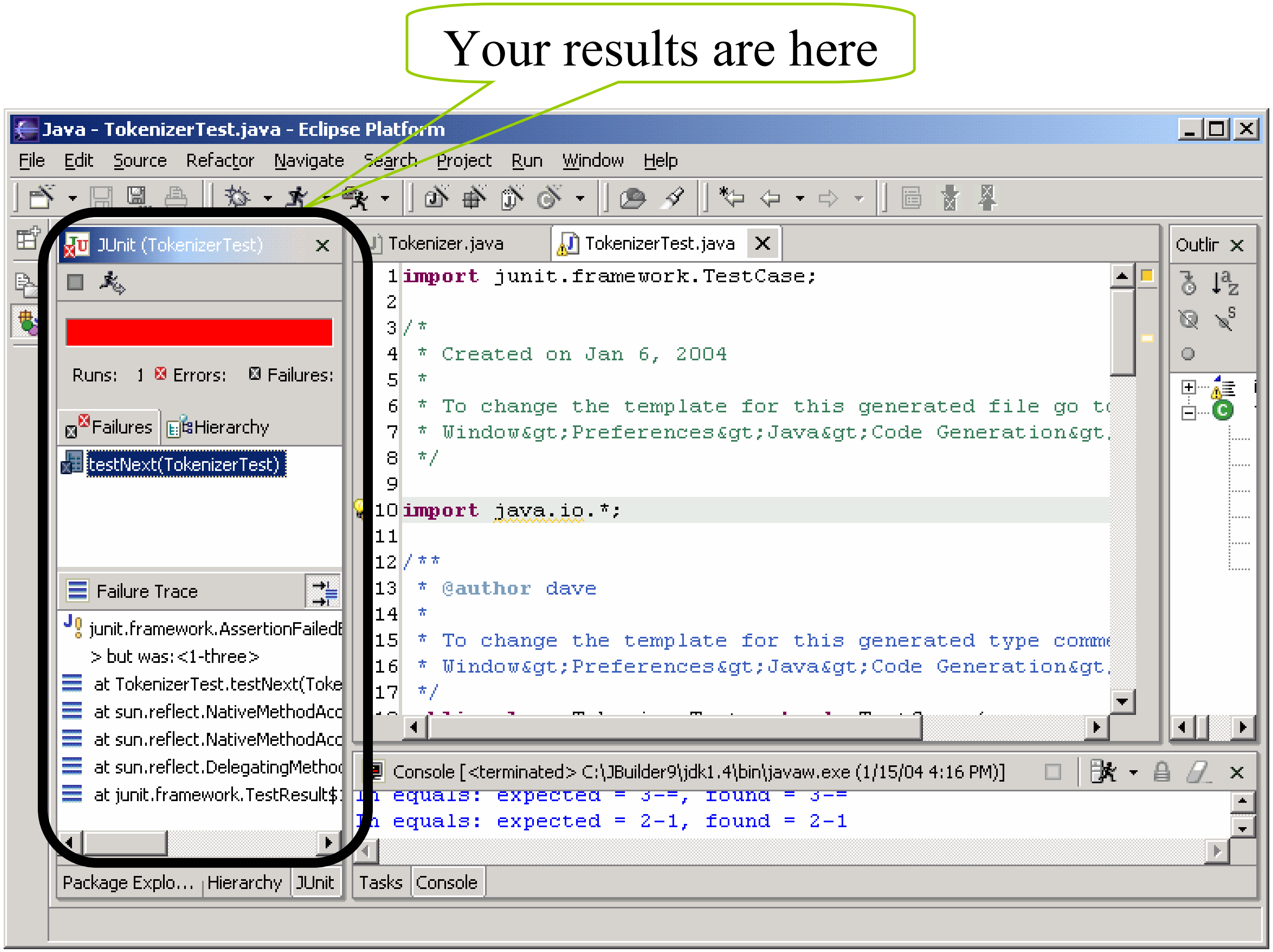


```
import junit.framework.TestCase

/*
6, 2004
emplate for t
rences&gt;Jav
import java.io.*;
```

Third, Run As → JUnit Test

# Results


Your results are here
Java - TokenizerTest.java - Eclipse Platform
File Edit Source Refactor Navigate Search Project Run Window Help
JUnit (TokenizerTest)
Runs: 1 Errors: Failures:
Failures Hierarchy
testNext(TokenizerTest)
Failure Trace
Tokenizer.java TokenizerTest.java
Outlir
Package Explo... Hierarchy JUnit
Tasks Console

```
junit.framework.AssertionFailedE
> but was:<1-three>
at TokenizerTest.testNext(Toke
at sun.reflect.NativeMethodAcc
at sun.reflect.NativeMethodAcc
at sun.reflect.DelegatingMethoc
at junit.framework.TestResult$:
```

```java
import junit.framework.TestCase;

/*
 * Created on Jan 6, 2004
 *
 * To change the template for this generated file go to
 * Window&gt;Preferences&gt;Java&gt;Code Generation&gt;
 */

import java.io.*;

/**
 * @author dave
 *
 * To change the template for this generated type comme
 * Window&gt;Preferences&gt;Java&gt;Code Generation&gt;
 */
```

```
Console [<terminated> C:\JBuilder9\jdk1.4\bin\javaw.exe (1/15/04 4:16 PM)]
In equals: expected = 3-=, found = 3-=
In equals: expected = 2-1, found = 2-1
```